HYDRO - ELECTRIC POWER DEVELOPMENT
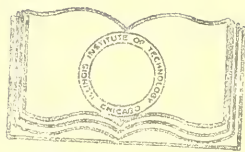# ON THE TALLAPOOSA RIVER IN ALABAMA

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ARMOUR INSTITUTE OF TECHNOLOGY

1912

Proposed

Hydro-Electric Power Development

on the

Tallapoosa River in Alabama.

A THESIS

PRESENTED BY

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In these days of electrical progress when the demand for power is increasing daily, a good deal of attention is being given to the question of how to supply that demand in the most satisfactory way and at the lowest cost to all parties concerned. Steam, gas, gasoline, oil and water are used successfully as power for generating electricity, but where natural power in the form of falling water is plentiful, the very best opportunity for the generation of electric power is afforded. It is the purpose of this paper and the drawings which accompany it to set forth the complete design of a plant suitable for utilizing the energy of one of the water powers of Alabama. This waterpower is located on the Tallapoosa river in the state of Alabama and is known as the "Cherokee Power Site." It is in the east central part of the state and is about eighteen miles south of Sturdevant and about thirty miles northeast of Montgomery. It is capable of developing forty-two thousand horse power and its qualifications as a power site are considered exceptionally good.

At this point the Tallapoosa river channel converges until it is only three hundred feet wide, as can

be seen by referring to the contour map, Plate 1. On
either side of the river the banks rise quite abruptly
to a height of one hundred feet above the low water
mark of the stream and are of such contour that a dam
giving an eighty foot head of water could be con-structed.
The construction of this dam would back the water up for
twenty miles and would create a reservoir the average
width of which would be half a mile, and the storage
capacity of which would be about five million cubic feet.
At the site of the dam the bed and banks of the river are
of granite and the river bed proper is free from boulders
and deposit, conditions which greatly facilitate the
building and anchoring of a dam.

Just below the dam the river makes a sharp bend
toward the east. A high point of land is thus left pro-
jecting into the river channel. The power house would
be located on the south bank of this promentory and dir-
ectly behind it the bluff would be excavated to form a
forebay one hundred and eighty feet wide, three hundred
and fifty feet long and averaging thelve feet deep.
The floor of the forebay would average sixty-eight feet
above the low water mark of the river. Six large pen-

stocks, one for each generator water-wheel, and a
seventh smaller penstock for the exciter water wheel
would lead from the south end of the forebay to the
power house, a distance of about one hundred feet. The
screens and controlling gates would be placed at the south
or lower end of the forebay. A retaining wall runs a-
cross the lower end of the forebay and for a distance
of about one hundred feet north on either side of the
bay. At the end of the retaining wall on the west side
of the forebay the spillway begins and follows a north-
westerly direction to the opposite bank of the river.
The spillway is somewhat curved or convex in order to
better withstand the water pressure behind it. It is
divided into three sections, a main spillway and two
auxilliary spillways. The crest of the main spillway
is one foot lower than that of the auxilliary spillway,
the latter serving as an overflow during the flood stages
of the river. The main spillway spans the deepest
part of the river channell and is four hundred feet in
length and one hundred and five feet high at the deepest
part of the river. The auxilliary spillway on the east
side of the river proper is about three hundred and thir-
ty feet in length and that on the west is about three

hundred and forty feet long.   At the deepest section
of the river bed the base of the dam is one hundred
and fifteen feet in width and the bases of other section
are in proportion.   The different sections of the spill-
way and retaining wall are shown in an accompanying
drawing, Plate #2.   Another drawing gives the plan view
of the entire dam, Plate #3.   Most of the retaining wall
will be thirty five feet high and twenty six feet wide
at the bottom.   The top is sixteen feet wide.   The
spillway will be built of large blocks of granite quar-
ried from the surrounding hills and will be faced with a
layer of masonry and rough rocks.

The following are the calculations made for the
spillway and retaining wall:-

The cross section of the dam was divided into
ten sections and the area of each section was measured
with a planimeter.   The areas are as follows:- Sec-
tion C C.

Section 1 - 144 sq. ft.   Section 6 - 616 sq. ft.

"   2 - 280 "   "   "   7 - 728 "   "

"   3 - 368 "   "   "   8 - 822 "   "

"   4 - 460 "   "   "   9 - 973 "   "

"   5 - 554 "   "   "   10 -1902 "   "

Total area of section 6847 sq. ft. (Sect. C.C.)

Assume 1 cu. ft. of granite weighs 150# .

Total weight of unit length (1 ft.) of dam (or spill-
way) at section C-C. 150 x 6847 = 1,027,050# = 513.5 tons.

The spillway is 134 feet wide at section C - C.

$$\frac{513.5}{134} = 3.83 \text{ tons per sq. ft.} = 7660\# \text{ per sq. ft.}$$

$$\frac{7660}{144} \quad 53\# \text{ per sq. in. average pressure.}$$

Maximum pressure 95.5 x 150 = 14320# per sq. ft. equals

$$\frac{14320}{144} = 100\# \text{ (almost) per sq. in.}$$

$\frac{47 \times 105.5}{2}$ x 62.5 = 155,000# total weight of water
wedge above section C-c for unit length.

$\frac{(105.5)^2}{2}$ x 62.5 = 348000# total horizontal pressure
on water side of dam.

Resultant (total) water pressure normal to water side of
dam. $\sqrt{(155000)^2 + (348000)^2}$ = 381000#

Tangent of the angle between the vertical and
the water side of dam $\frac{47}{105.5}$ = .445 or
$\frac{\text{vertical water pressure}}{\text{Horizontal water pressure}}$ = $\frac{155000}{348000}$ = .445

The angle equals 24 degrees.

Resultant of weight of dam (spillway) and water pressure
normal to water side (by graphical method - see Plate #2)
equals 650 tons.

Coefficient of friction for granite   granite   .70

Resistance of dam to sliding   .70 x 1,027,050 718935#.

Horizontal force   348000#

There fore section C-C is safe against sliding.

Factor of Safety 2.075

      Section A - A.

Area   1252 sq. ft.

Weight of unit length 1252 x 150 188000#   94.0 tons.

$\frac{94}{5075}$ = 1852 tons/sq. ft. = 3705#/sq. ft.

    $\frac{3705}{144}$ =   2575#/sq. in.

    $\frac{20.12 \times 45.6}{2}$ x 62.5 =   28,700# total weight of
water wedge above unit length of dam.

$\frac{(45.6)^2}{2}$ x 62.5 = 65000# total horizontal pressure on
water side of dam.

$\sqrt{(28700)^2 + (65000)^2}$ =   71,100# = 35.55 tons -
Resultant water pressure normal to water side of dam.

Resultant of weight of sectional water pressure resultant

equals 144 tons (by graphical method - see Plate #2)

Total weight of section 188,000#

u equals .7

P = u f = .7 x 188,000 = 131,600# resisting force of
section against sliding.

Horizontal water pressure 65,000#

Section is safe against sliding.   F.S. = 2.022.

Sections B.-B. and D.-D.

Area - 3972 sq. ft.

3972 x 150 = 596,000# = 298 tons.

$\frac{298}{85.5}$ = 3,485 tons per sq. ft. = 6970#/sq.ft.

$\frac{6970}{144}$ = 48.4#/sq. in.

$\frac{36.5 \times 85}{2}$ x 62.5 = 96,800# total weight of water

wedge above unit length of section.

$\frac{(85)^2}{2}$ x 62.5 = 225,500# total horizontal water pressure

on dam.

$\sqrt{(96800)^2 + (225,500)^2}$ = 245,500# = 122.757 tons -

Resultant water pressure normal to dam.

Resultant of weight of dam and water resultant 368.75

tons (by graphical method - see Plate #2)

Total weight of section - 596,000#

u = .7

P = u f = .7x596000 = 417,200# resisting force of the

dam (sec B B or D D) against sliding.

Horizontal force against section 225,500#

Therefore sections B B and D D are safe against sliding

F.S. 1.85.

Section E - E.

Area = 1806 sq. ft.

1806 x 150 = 271000# ≅ 135.5 tons.

$\frac{135.5}{59.5}$ = 2.28 tons/sq. ft. ≅ 4560#/sq. ft.

$\frac{4560}{144}$ = 31.65# per sq. inch.

$\frac{24.25 \times 55.7}{2}$ x 62.5 = 42,250# total weight of water wedge above unit length of section.

$\frac{(55.7)^2}{2}$ x 62.5 = 96750# total horizontal pressure on water side of dam.

$\sqrt{(42250)^2 + (96,750)^2}$ = 105,600# ≅ 52.8 tons. - Resultant water pressure normal to dam.

Resultant of weight of dam and water pressure normal to it 167.5 tons (obtained graphically - see plate #2)

Total weight of section 271000#

u = .7

P = u f = .7 x 271000 = 189700# resisting force exerted by dam (section E-E) against sliding.

Horizontal water pressure 96750#.

Therefore section E - E is safe against sliding. F.S. equals 1.96

Section C - C.

$$N = \frac{1}{2} - \frac{1}{3} \frac{h'y'}{c'} \times \frac{b'+ b''}{b'} \qquad\qquad h' = 105$$

$$= \frac{1}{2} - \frac{1}{3} \frac{105 \times 150}{60,000} \times \frac{107 + 13}{107} \qquad y' = 150$$

$$b'' = 13$$

$$= \frac{1}{2} - \frac{1}{3} \times 0.262 \times 1.12 \qquad\qquad c' = 60,000$$

$$b' = 107$$

$$= \frac{1}{2} - 0.098 = 0.402$$

$$N = \frac{1}{6} \left[\frac{2\ c'b'}{b'y'\ (b'+ b'')} - 1 \right]$$

$$\frac{1}{6} \left[\frac{2 \times 60,000 \times 107}{105 \times 150 \times 120} - 1 \right]$$

$$\frac{1}{6} \left[6.8 - 1 \right] = \frac{1}{6} \times 5.8 = 0.96$$

Therefore section C - C is safe.

Sections B — B and D - D.

$$N = \frac{1}{2} - \frac{1}{3} \frac{h'y'}{c'} \times \frac{b'+ b''}{b'} \qquad H \qquad h' = 80$$

$$= \frac{1}{2} - \frac{1}{3} \times \frac{80 \times 150}{60,000} \times \frac{130 + 13}{130} \qquad y' = 150$$

$$b' = 130$$

$$= \frac{1}{2} - .0735 = 0.4265$$

$$b'' = 13$$

$$N\ \frac{1}{6} \left[\frac{2 \times 60,000 \times 130}{80 \times 150 \times 143} - 1 \right] \qquad c' = 60,000$$

$$\frac{1}{6} \left[9.08 - 1 \right] = \frac{1}{6} \times 8.08 = 1.35$$

Therefore sections B - B and D - D are safe.

Retaining Wall.

For Unit Length:-

16 x 35 =   560 cu. Ft.

1/2 x 8 x 35 =&140   "   "
      700   "   "   total volume of unit length
      150
    105000# total vertical pressure.
     0.7
    73500.0# resisting force against sliding.

Horizontal pressure of water against wall (normal) equals

$\dfrac{(30)^2 \times 62.5}{2}$ = 28,120#

Facotr of safety $\dfrac{73500}{28,120}$ = 2.61

Horizontal pressure of water against wall (high-water)

equals $\dfrac{(35)^2 \times 62.5}{2}$ = 38,200#

Factor of safety $\dfrac{73500}{38200}$ = 1.92

Calculations for Penstocks and Fore Bay.

Number of generating units = 6

H.P. of one generating unit = 6000.

Q = $\dfrac{36000 \times 550}{62.5 \times 80 \times .80}$ = 4950 or say 5000 sec. ft.

Velocity of water in head race - assumed as 4 ft/ sec.

Area $\dfrac{5000}{4}$ = 1250 sq. ft.

Area through screens $\dfrac{5000}{2}$ = 2500 sq. ft.

Using 6 circular steel penstocks, each to carry $\frac{5000}{6}$ or 840 sec. ft., at full gate; assume a maximum velocity of 12 ft. per sec. in the penstocks. -

Area $\frac{840}{12} = 70$ sq. ft. $= \frac{\pi D^2}{4}$

$D = \sqrt{\frac{70}{.7854}} = 9.46$ or say 10 ft.

Therefore diameter of penstocks   10 ft.

Forebay   Cross-section:-

   Area - 1250 sq. ft.

   Width - 180 feet.

Then depth $= \frac{1250}{180} = 6.95$ ft.

Increase this depth to 12 ft.

The building.

The main building is approximately two hundred feet long, seventy feet wide and forty-five feet high. At the center of the downstream side of the building an extension projects a few feet from the main structure; the extension is fifty feet long and fifty five feet in height. The walls will be of masonry and the framework of steel. The entire roof is supported by steel trusses. The floors are of concrete reenforced and supported by I-beams. Lighting of the building is accomplished by numerous side windows in the daytime and by arc and incandescent lamps at night.

The generating room runs the full length of the building and is sixty-nine feet in width. In this room are located the water wheels, the generators, the motor driven exciters and the water driven exciter. At one side are the transformers arranged in groups of three, each group being enclosed in a masonry compartment. Each transformer is mounted on a separate truck which runs on small rails set in the floor. By this means any transformer may be disconnected and pushed right out on to the generating floor where it can be handled by crane. For moving heavy machinery a crane of sixty-nine foot span runs the whole length of the generating room. The structure which supports the crane consists of built up

coloumns of steel and these columns form part of the
main structure itself. A short spur of railroad track
extends into one corner of the generating room for the
purpose of facilitating the installation and removal
of heavy machinery.

On the ground floor and running parallel with
the generating room for nearly the full length of the
building is a room thirty feet wide for auxillary ap-
paratus. This "room" is in reality several smaller rooms
for some of the auxillary apparatus is partitioned off
into small rooms. Here are located the piping, tanks,
pumps and other necessary apparatus for handling the
oil for insulating the transformers and the water for
cooling them. The bank of three transformers used
for the station load with its oil switch and the com-
pensator for starting the induction motor exciter sets
are also located in this room. No definite qall di-
vides this space off from the generating room but the
masonry compartments for the transformer banks are ranged
so closely along one side of the generating room that
they practically form a wall between the two.

Directly above the room for auxillary appara-
tus is a gallery of the same width as the room below it
and running the full length of the structure. It is

open on the side facing the generating floor and at
its center where the bench board is located it pro-
jects slightly into the generating room in order that
the operator may have a better view of the machines
he is controlling. Directly behind the bench-board and
just back of that a row of oil switches is placed. These
are the machine switches and are six in number. Next
farther back are the masonry compartments for the high
tension bus bars.   These compartments with their bus-
bars are divided into two sections and a sectionalizing
oil switch is inserted between them.   Back of the high-
tension bus-bars are located the two line oil switches
and on the rear wall of the gallery vertical brick com-
partments are built into the wall to carry the high-
tension line wires to the wire tower above.   The gallery
is reached by a circular stairway at either end.

        Above the center of the gallery is located the
wire tower, also reached by a circular stairway located
in the center of the switch board gallery. It is about
fifty feet long and forty-five feet wide and extends
some ten feet above the roof of the main structure. In
it are installed two sets of electrolytic lighting ar-
resters and the necessary horn-gaps, choke coils, and

disconnect switches.   On one side of this tower are the six outlets, one for each of the six line wires forming the two three-phase transmission lines.

An office is provided for in one corner of the building on the main floor. In another corner of the building is located a room for storage purposes and a small machine shop room. The locker room is located in the gallery above the office.

Hydraulic Machinery.

The water for operating the turbines first passes through double screens placed just in front of the openings to the penstocks in the retaining wall at the lower end of the fore-bay.   The screens consist of iron bars laid parallel to each other and an inch or two apart.   Each screen is supported on an angle-iron frame work upon which it slides.   When it becomes nesessary to clean the screens they may be hoisted out of the water by means of a small crane or derrick which runs along the top of the penstock wall on rails.   The purpose of the screens is to prevent any foreign material from getting into the water wheels and causing trouble there.

In the mouth of each penstock is a gate valve which controls the flow of water into the penstock connected

with it. A motor connected to this valve and serves both for opening and for closing it. Each valve has its individual motor and each motor is arranged so that it may be controlled from the main switchboard within the station..

From the gate valves in the retaining wall six circular steel penstocks each ten feet in diameter carry the water directly to the water wheels withinthe station. The penstocks will be laid in trenches excavated out of the solid granite bank and will be anchored to the same. There are six water wheels or turbines each rated at six thousand horse power installed in the plant. They are made by the S. Morgan Smith Company of York, Pa., and are of the inward flow reaction type. There are two wheels mounted on the same horizontal axle in each turbine. The water from each penstock divides just before reaching the turbine and half goes to each wheel. The water enters from below at the rim of the wheel and leaves at the center of the wheel. A common discharge pipe located between the two wheels of each turbine serves to reunite the two streams of water after they have passed by separate paths through the two wheels and to conduct the water to the reenforced

concrete passage way under each turbine which leads to the tail-race. Each turbine is governed by a Lombard hydraulic governor which in turn is controlled from a switch on the bench board. The governor is mounted on the same base with the turbine and between its two wheels.

A penstock four feet in diameter supplies water to a small turbine used for driving an emergency exciter. Water for cooling the transformers is conveyed to the station from the forebay by a separate twelve inch main and after passing through a reducing valve is distributed to the cooling coils of the transformers through a system of piping shown in detail in the accompanying drawings Page 4, and #5.

Transformer Oil System.

The system for handling the transformer oil consists of three tanks, two oil pumps and a suitable system of piping. Referring to the drawings Plate #4, tank #1 is for old oil, tank #2 is for new oil, and tank #3 is for filtering and drying old oil. Tanks No. 1 and No. 2 are cylindrical tanks located under the floor of the auxilliary apparatus room. Tank #3 is square and is placed on the main floor.

The two oil pumps are also located on the main floor and are driven by small electric motors. Pump No. 1

handles old or drain oil only and transfer it form tank
No. 1, the old oil tank, to tank No. 3, the filtering
tank.   The old oil drains by gravity from the transformers
cases   into   tank No. 1. One of the principle reasons
forfor gravity drain is that the transformer cases may
be promptly emptied when a transformer burns out, even   .
though the oil be burning. It is necessary therefore t
that tank No. 1 and the piping leading from the trans-
former cases to it be perfectly air tight if they are to
properly perform the function of extinquishing the flames
from burning oil in an emergency. Pump No. 2 performs
two duties.   It may be used either to pump new oil from
tank No. 2 into the trnasformer cases or to pump filtered
oil from tank No. 3 into the transformer cases.   Tank
No. 3 and the two pumps are on the main floor level, but
are enclosed in a separate oil room. This room also
contains the pits in which tanks No. 1 and No. 2 are
placed.   An iron grating floor covers the pits. Two
oil mains run along behind the transformer rooms, one
for filling the transformer cases and the other for drain-
ing them.   By the use of proper valves, the locations
of which are shown on the drawings, the transfer of oil
can be regulated at will.   New oil on arriving at the

plant, is emptied into a receiving funnel on the generating floor from whence it flows by gravity into tank No. 2 for new oil.

Electrical Equipment.

Alternators.

The Alternators are six in number and are set in a row along the center of the generating floor, three on each side of a space in the center set apart for exciters. Each alternator is of 3500 kw. rating at unity power factor and generates 6600 volts at 60 cycles. Each machine is directly connected to a hydraulic turbine. These alternators are of General Electric Company manufacture. Their dimensions and spacings are given in detail on the drawings.

Exciters.

In the center of the generating floor are three exciter sets, two of which are motor driven and the third turbine driven. The two motor driven exciters are each of 150 kw. capacity and generate direct current at 125 volts. They are each driven by a 200 horse power induction motor of the squirrel cage type operating at 440 volts on 60 cycles. These motor generator sets are direct connected. One compensator serves to start either motor

a double throw switch mounted on each motor, serving to connect it with the compensator or the line when the motor is to be started. The third exciter is of 300 kw. capacity and generates direct current at 125 volts. It is directly connected to a 400 horsepower hydraulic turbine. The turbine is fitted with a Lombard govenor controlled from the switch board. All three exciters are flat compounded. The exciters and the two induction motors are of General Electric make and the turbine is furnished by the S. Morgan Smith Company. The exciters capacity about three percent of the total output of the station.

<div align="center">Transformers.</div>

There are six sets or banks of main transformers, one bank for each alternator. Each transformer is rated at 1250 kw at unity power factor. This gives a rating of 3750 Kva for each bank of transformers - a rating slightly in excess of the alternator rating. Each bank is connected delta on both the low and the high sides and steps the voltage from 6600 volts up to 66000volts. The grequency is 60 cycles. These transformers are water cooled and oil insulated. They are furnished by the General Electric Company.

A special bank of three transformers furnishes
power for the station load. These transformers step
the voltage down from 66,000 volts to 440 volts. Each
transformer is rated at 156 kw. at unity power factor
and the bank is rated at 468 kw. The frequency is 60
cycles. Insulation and cooling are both by oil. The
connections are delta on both the high and low sides.
The General Electric Company furnish these transfor-
mers also.

There are eighteen potential transformers in the
plant, three for each alternator. They are all placed
on the low side of the power transformers and step from
6600 volts down to 125 volts for the instruments on the
switch board. There are two current transformers on
the low side and two on the high side of each of the six
main power transformer banks. The current from the sec-
ondary of these is used for operating switchboard instru-
ments and relays. There are three current transfor-
mers on each of the two out going lines. They furnish
current to switchboard instruments and relays. On the
special bank of transformers for the station load there
are two current transformers on the low side. All trans-
formers are for 60 cycles and are of General Electric
make.

Oil, Switches.

On the low side of each main bank of transformers

between the alternator and the transformer terminals
is placed a K2 hand operated oil switch.   These K2
switches are equipped with time-limit overload relays
mounted at the switch.

On the high side an H3 oil switch is placed
between the terminals of each transformer and the high
tension bus-bars.   These switches are all remote con-
troll and are equipped with two-pole time-limit over-
load relays.   The control switches and relays are mounted
on the bench board.

The high tension bus-bar is divided into two
sections and between them is mounted a non-automatic H3
oil switch, the control switch of which is mounted on
one of the panel board sections inthe gallery.

The two out-going lines are each equipped with
an H3 automatic oil switch and with a three-pole time
limit overload relay.   The remote control switch and
the relay are mounted on the panel board in the gallery.

On the high side of the special station load
transformer bank is placed a non-automatic H3 oil switch
with remote control switch on the panel board in the
gallery.

All oil switches are of General Electric con-

structure and are motor operated.   On the drawings
switches 1, 2, 3, 4, 5, and 6 are the machine switches
for alternators 1, 2, 3, 4, 5, and 6 respectively,
switch 7 is the high tension bus sectionalizing switch,
switches 8 and 9 are the two line switches and switch
10 is the station load switch.

Switches, Instruments and Control Apparatus.

The main control board is a bench switch board
consisting of nine panels or sections.   Six of the
sections, three on each end, are generator sections and
the three center sections are exciter panels.   Each
section consists of a bench panel on which are mounted
the control switches, signal lamps, and plug switches,
and a small vertical panel just above it on which the
instruments are mounted.   The six alternator panels are
duplicates of each other and are arranged in this manner.
On each bench panel are mounted four remote control
switches handles which control the alternator machine
switch, the alternator field, the motor operated rheo-
stat, and the turbine governor.   The location of these
switch handles is given on the drawing of the switch
board.   The control switches are of the Westinghouse
type and are used on 125 volt circuits.   Power for op-
erating these switches is taken from the exciter bus.

Each control switch has two signal lamps, a red one to indicate when the switch is closed and a green one to indicate when it is open.

On the small vertical panel above each alternator bench panel are mounted six horizontal edge-wise indicating instruments - three ammeters, a voltmeter and a fieldammeter and an indicating wattmeter. The wires leading to these instruments are concealed within the pillars which support the vertical part of the board. The vertical instrument panels are supported on pillars so as to leave an open space between these panels and the bench panels through which the operator may see the machines he is controlling. On the front of each alternator section of the bench board are mounted a polyphase intergrating watt-hour meter and a two pole relay. The relay governs the oil switch between the high tension terminals of the transformers corresponding to that alternator and the high tension bus.

At one end of the bench board is a swinging panel which carries a synchroscope and a frequency meter. The wiring of the bench board is made accessible through two hinged doors, one at each end of the board.

The three central panels or sections of the bench

board are exciter panels.   The center one of the three
governs the turbo-exciter and the other two govern the
two motor driven exciters.   On the bench panel of the
turbo-exciter section are mounted three switch handles -
one governs the govenor on the turbine, the second governs
the field rheostat on the turbo-exciter and the third
coverns the exciter switch which connects the exciter
with the exciter bus.   The other two exciter panels have
mounted upon them only two switches each, a rheostat
control switch and an exciter machine-switch.   On the
vertical panel above each exciter bench-panel are mounted
an exciter voltmeter and an exciter ammeter.

        The bench board is mounted on a small project-
ing balcony at the center of the switchboard gallery
with its back to the generating room.   A few feet from
the front of the bench board is a vertical switchboard
consisting of two panels.   On one panel are two switch
handles, one of which controls the sectionalizing switch
and the other of which controls one of the outgoing line
switches.   The other panel also has two switch handles
upon it - one controls the H3 switch on the high side of
the station bank of transformers and the other controls
the oil switch on the second outgoing line.   At the top

of each panel are three line ammeters and at the bottom of each panel is a three pole time limit overload relay for the line.

On the main floor underneath the gallery is single vertical panel board for the 440 volt station load. On this board are mounted an ammeter, a voltmeter, a polyphase integrating watt hour meter, and a three-pole single-throw knife switch. This board controls the output from the secondary of the station bank of transformers.

All remote control switches on the bench board are Westinghouse type and all remote control switches on the panel boards are General Electric Type. All ammeters, voltmeters, and indicating wattmeters are of the Thompson horizontal edgewise type. Integrating watthour meters are General Electric type; likewise the synchroscope. The frequency meter is of the Thompson type. All the panels of the bench board and the vertical boards are of blue slate, enameled and polished.

Equipment in the Wire Tower.

The wire tower, located above the center of the switchboard gallery, contains, principally two sets of aluminum cell, electrolytic lightning arresters, one for each outgoing line. Each set consists of four arrester tanks, three of which are inserted between the line wires and the fourth between line and ground. Each set of

arresters is provided with three horn gaps and a switch
for interchanging the connection two of the cells when
charging them.   The arrester cells and horn gaps are
mounted on a frame work built of iron pipes.   The ar-
resters are charged by the General Electric Company's
sector device. Each arrester is provided with a set of
disconnects for insolating it from the line when an
occasion to do so arises.   In the wire tower are also
mounted the choke coils, one for each line wire. These
choke coils are of the hour glass type.

The two out-going three phase lines leave the
building from one side of the wire tower through hooded
outlets.   Each three phase line has a separate hood ex-
tending over the three outlets for that line.   The hoods
are constructed of reenforced concrete and are designed
to thoroughly protect the outlets from the weather. The
apparatus installed in the wire tower is all of General
Electric manufacture.

General Wiring Scheme.

and

System of Control.

In the wiring scheme each alternator and its set
of three transformers form a unit, that is, each alternator
is always used with the same bank of transformers. A K2

hand operated oil switch is inserted between each genera-
tor and its transformers.   This switch is equipped with
a time-limit overload relay which will protect the gen-
erator in case all other relays fail.   It was made a
hand operated switch because it seldom has to be opened
and never under load conditions except when opened by
the relay and also because it is a much less expensive
switch than the H3 remote control type.

On the high side of the transformers each machine
has its own H3 remote control switch between the high
side of the transformer bank and the high side of the
transformer bank and the high tension bus. All paral-
lelling of machines is done on the high tension side.
The high tension bus is divided into two parts and an H3
remote control switch is inserted between these two
sections;   this is termed the bus sectionalizing switch.
Three generating units feed onto one section of the high
tension bus and three onto the other.

One bus section connects directly to one of the
out-going lines through an H3 remote control switch and
the second bus section is connected in a similar manner
to the other line.   All H3 switches are motor operated
and controlled from the switch board gallery.   They are

all equipped with time -limit overload relays, either
two pole or three pole as specified elsewhere, except
the sectionalizing switch which is not-automatic. All
oil switches are provided with a set of disconnects on
each side of the switch in order that it may be entirely
disconnected from the system for inspection and repairs.

The K2 oil switches are mounted in masonry com-
partments adjacent to their respective transformer banks
and the relay for each switch is placed in the same com-
partment.   The H3 switches are mounted in masonry com-
partments, each phase being placed in a cell by itself.
The relays for these switches are mounted either on the
bench board or on the panel baord in the gallery as des-
cribed in another place.   All connections to H3 switches
are made from below while the connections to K2 switches
are made from above.

The high tension bus bars are of hollow copper
tubing.   They are placed in masonry compartments, each
conductor being mounted in a compartment by itself. All
low tension wiring that has to traverse the floor space
between the generators and the transformers is carried
in shallow trenches built into the concrete floor for that
purpose. Where open wiring is not objectionable the wires

are supported on suitable porcelain insulators.   In
laying out the wiring of the station the aim was to
make it conform as nearly as possible with the principles
of modern practice and at the same time to make it
simple.

<p style="text-align:center">Some Date on the Plant.</p>

Number of water wheel units = 6.

Horse power of each water wheel= 6000 H.P.

Total horse power of wheels 6 x 6000 = 36000 H.P.

Efficiency of wheels 80%   (Assumed)

Power to be delivered to wheels $\frac{36000}{.80}$ = 45000 H.P.

$$H.P. = \frac{Q \times H \times y}{550}$$

where:- H.P.= horse power delivered to wheels.

      H.= effective head of water on wheels in feed.

      y. =density of water.

      Q.= quantity of water supplied to wheels in
          second-feet.

$$45000 = \frac{Q \times 80 \times 62.5}{550}$$

Therefore $Q = \frac{550 \times 45000}{80 \times 62.5}$ = 4750 second feet.

From tables on page 44 "Water Powers of Alabama" by Hall
we get:-

Q = 4070 second feet (at Sturdevant).

Also, it is stated there that the flow of water at the
Cherokee power site is one fifth to one third greater
.than at Sturdevant.

Therefore, at the power site

$$Q = 4070 + \frac{4070}{5} = {}^{4070} + 814 = 4884 \text{ sec. ft.}$$

$$Q = 4070 + \frac{4070}{3} = 4070 + 1353 = 5423 \text{ sec. ft.}$$

Both of these values of Q are greater than the required
4750 sec. ft. to run the plant so that there is suffi-
cient flow of water to insure satisfactory operation
of the water wheel.

   Power delivered to generators = 36000 H.P. equals

   = .746 x 36000 = 26850 K.W.

Number of generators = 6

Rating of each generator = 35000 K.W.

Total capacity of generators at full load = 6 x 3500
equals 21000 K.W.

Total overload capacity of station 26850 - 21000 equals
5850 K.W.

Overload on each generator = $\frac{5850}{6}$ = 975 K.W.

Percent overload that each generator may have to stand

= $\frac{975}{3500}$ x 100 equals 28%

The above figures are based on the assumption that the

efficiency of the generators is 100%. Now assume the
efficiency of the generators is 90% and we get the fol-
lowing results:-

Total overload capacity of station =26850 - $\frac{21000}{.9}$

equals 26850 - 23444 equals 3406 K.W.

Overload on each generator= $\frac{3406}{6}$ = 568 K.W.

Percent overload on each generator.= $\frac{568}{3500}$ x 100 = 19.7%

The last set of figures would correspond more nearly
with actual running conditions.

Exciters.

Assume 2% of total generator capacity for exciters.
Then exciter output =.02 x 21000 = 420 K.W.
Assuming 90% efficiency.
Exciter input = $\frac{420}{.9}$ = 455 K.W.
Increase this to 600 K.W. to allow for station lightingm
motor power for operating control gates, signals and other
station load.

The exciter capacity of 600 K.W. is divided
up among three exciters, two of which are driven by
direct connected induction motors and the third driven
by a direct connected water turbine.   The rating of

each motor driven exciters is 150 kw. and each is
driven by a 200 horsepower motor.   The turbo exciter
is rated at 300 kw. and is driven by a 400 horsepower
turbine.

PLATE #5.

Scale 1"= 4'
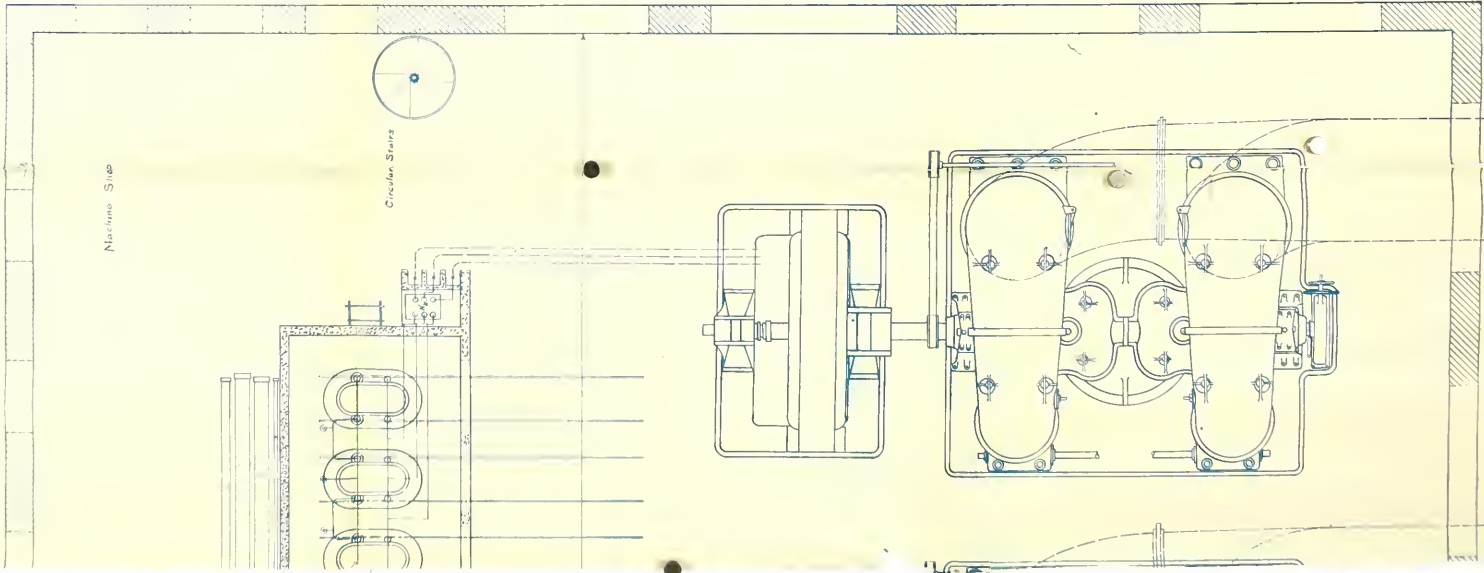
PLAN VIEW
OF
POWER HOUSE
FOR THE
PROPOSED HYDRO-ELECTRIC
POWER DEVELOPMENT
ON THE
TALLAPOOSA RIVER
TALLAPOOSA CO. ALA.

A THESIS
TO
ARMOUR INSTITUTE OF TECHNOLOGY
BY

Machine Shop

Circular Stairs

Gen ³

23'-3"

400 H.P Water Turbine
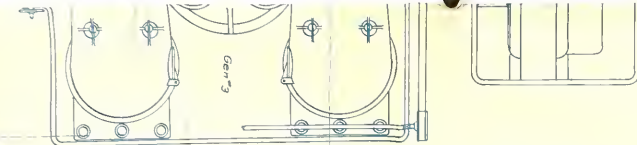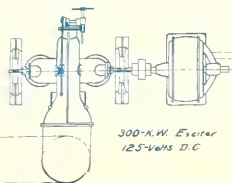
300-K.W. Exciter
125-Volts D.C.
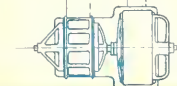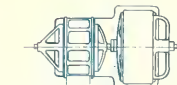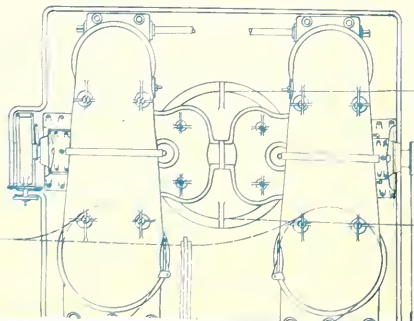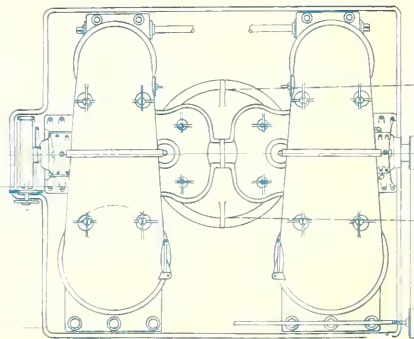
200-H.P. Motor   150-K.W Exciter
3-Phase, 60~.   125 Volt-D.C
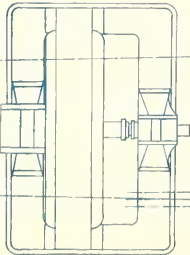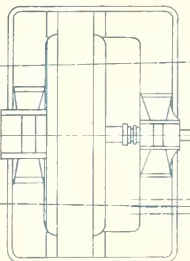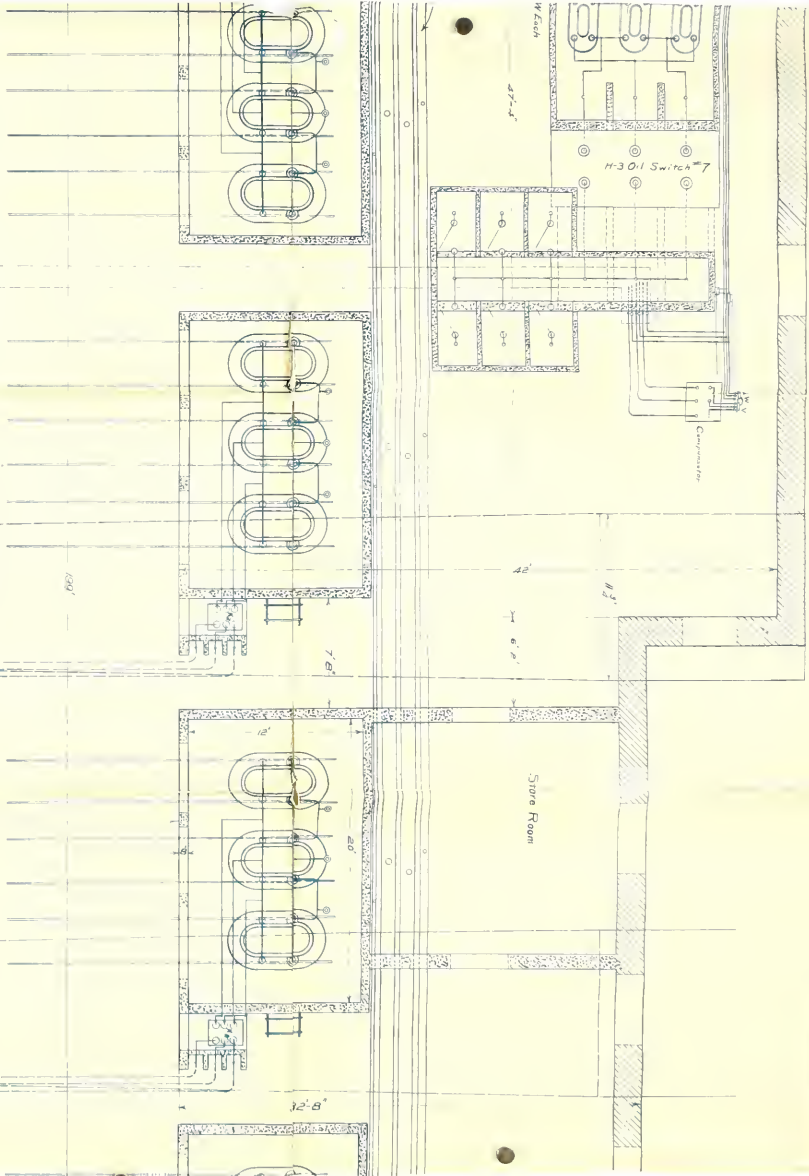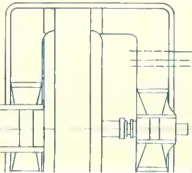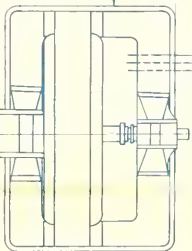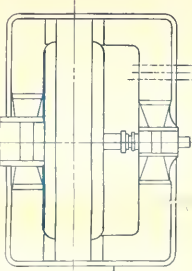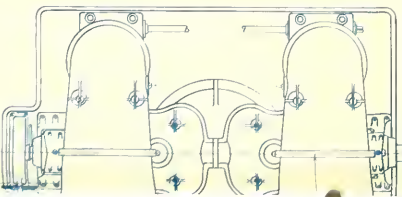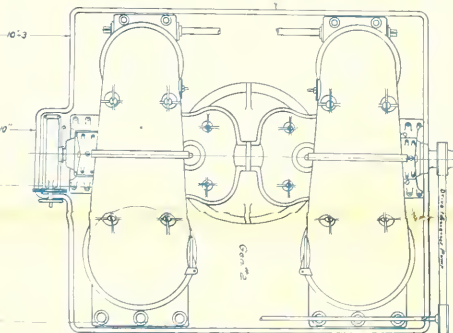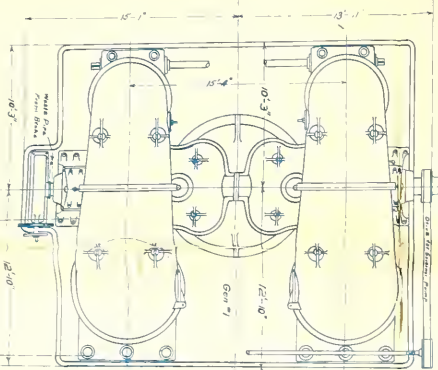
9'-1"

44'-7"

5'-9"

47'-1"

H-3 Oil Switch [#]7

.060"

42'

7'-8"

6'-2"

70'-7"

12'

Store Room

20'

6"

32'-8"

Cross-Section Through Double Screens, Retaining Wall and Penstocks

Scale ¼ = 1 FT

SIDE ELEVATION

OF
SCREENS PENSTOCKS & PLANT
FOR THE
PROPOSED HYDRO-ELECTRIC
POWER DEVELOPMENT
ON THE
TALLAPOOSA RIVER
TALLAPOOSA CO. ALA.

A THESIS
TO
ARMOUR INSTITUTE OF TECHNOLOGY
BY

S. Morgan Smith
Water Turbine
6100 H.P.
240 R.P.M.
6.0' Head

40 Ton Crane

PLATE # 4
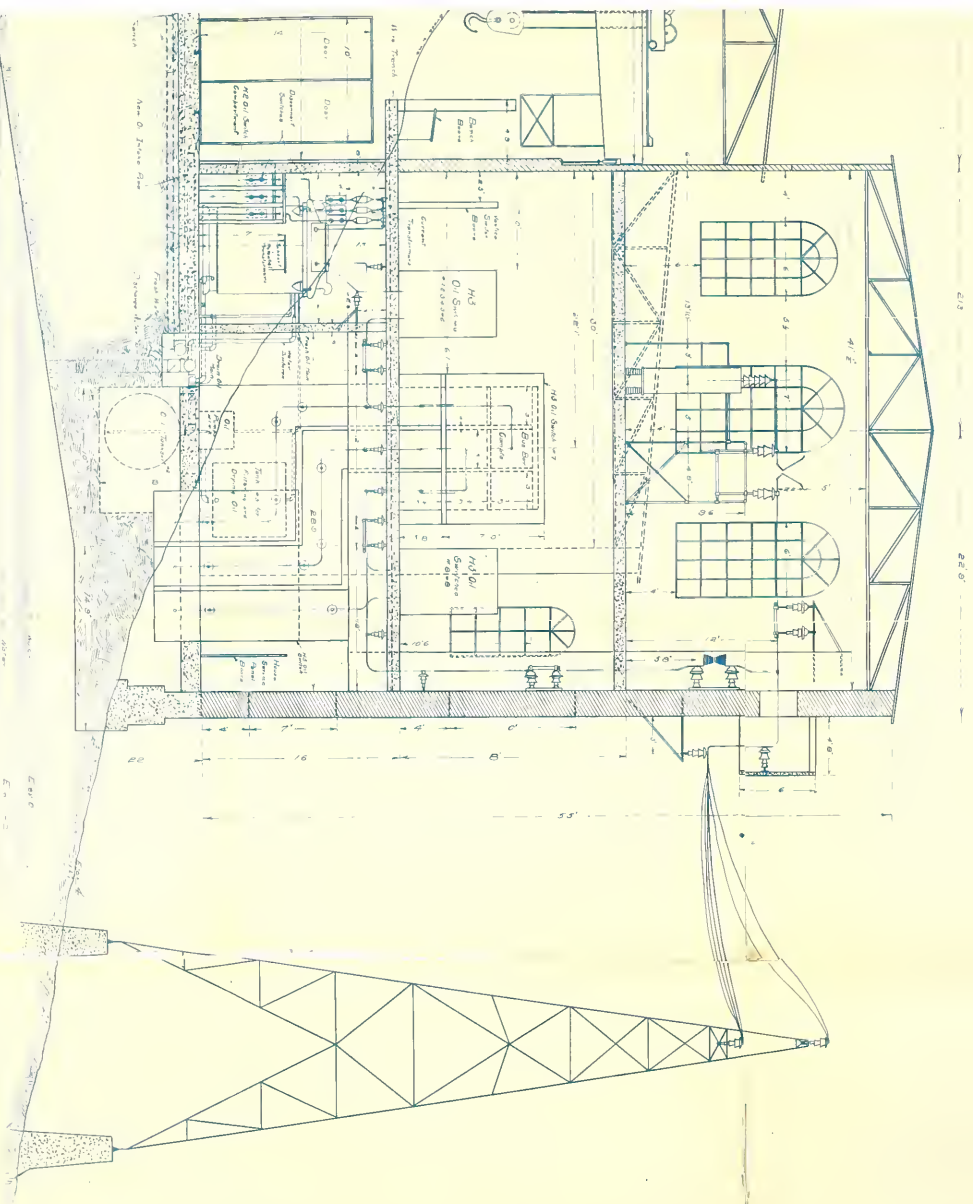
WIRING DIAGRAM

FOR THE
PROPOSED HYDRO-ELECTRIC
POWER DEVELOPMENT
ON THE
TALLAPOOSA RIVER
TALLAPOOSA CO. ALA.

A THESIS
TO
ARMOUR INSTITUTE OF TECHNOLOGY
BY

Harold O. P. Langstaff
Joseph Ifferis
Dwight A. Wheeler

PLATE #9

FEEDER #2

Locker and Toilet Room
13½'×19½'

←Circular Stairs

←3'→ ←3'-8'→

5'-4"

H-3 Oil Switch #1
Generator #1

8'-6"

←4'-2"→   6

30'-8"

17'

High Tension Bus Bar Compartment

Transformer Compartment Below

H-3 Oil Switch #2
Generator #2

H-3 Oil Switch #3
Generator #1

H-3 Oil Switch #8
Line #1

Vertical Board

Benchboard

Line Cells

H-3 Oil Switch #10

A

H-3 Oil Switch #4
Generator #2

H-3 Oil Switch #9
Line #2

H-3 Oil Switch #5
Generator #3

Lightning Arresters

Disc. Switches

Circular Stairs

42'

49'

3'-8"

8'

OPERATI
PROPOSED
POWER
TALLAP
TALLAPO

A

ARMOUR
Ha

NG GALLERY
FOR THE
HYDRO-ELECTRIC
DEVELOPMENT
ON THE
OOSA RIVER
OSA CO. ALA.

THESIS
TO
NSTITUTE OF TECHNOLOGY
BY

PLATES Nº 6-7.
Scale 4"=1"

M-3 Oil Switch Nº 6
Generator Nº 6

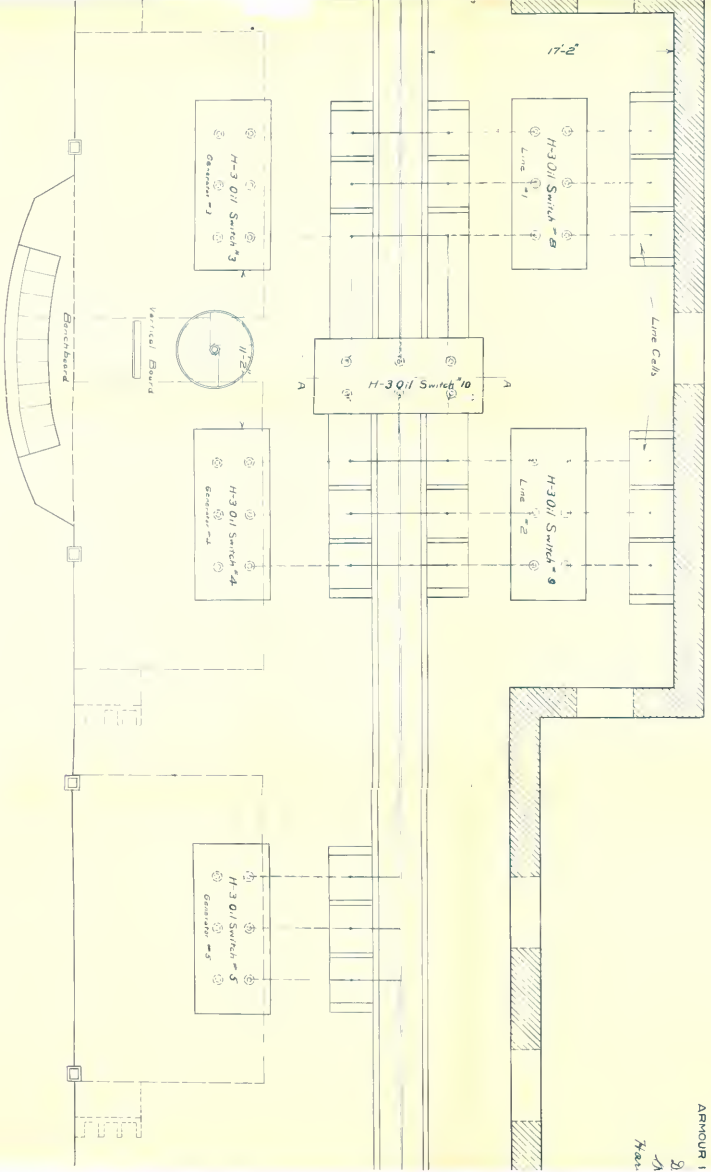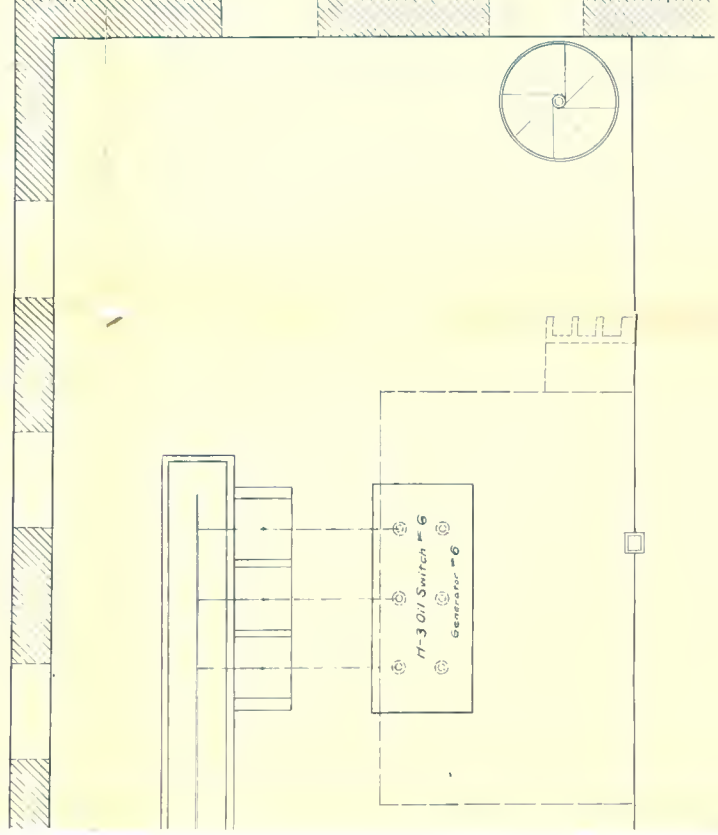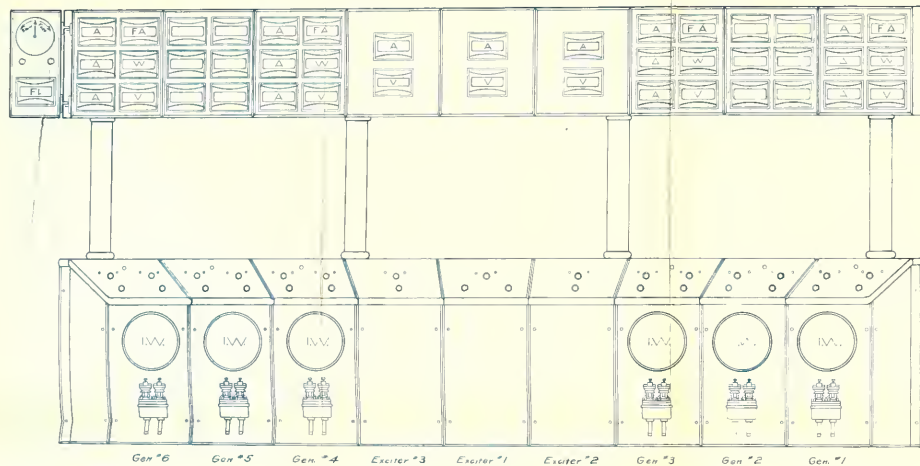**BENCHBOARD**

Gen. #6   Gen. #5   Gen. #4   Exciter #3 Motor   Exciter #1 Turbine   Exciter #2 Motor   Gen. #3   Gen. #2   Gen. #1

7'-8"
2'-6"
3'-2"
7 3/4"
3 1/4"
1'-10 1/2"

VERTICAL BOARD

H-3 Oil Switch #8
H-3 Oil Switch #7
H-3 Oil Switch #9
H-3 Oil Switch #10
Over Load T.L. Relay

Feeder Panel #1   Feeder Panel #2

Key Synchronizing Socket
Pilot Lights
H-3 Oil Switch #1
Motor Oper. Field Oil Switch
Gen. Field Rheostat Control
Turbine Governor Control
Exciter Field Rheostats
Exciter Oil Switches
Turbo-Exciter Gov. Control

18"
13'-4"
2'
1 7/8"
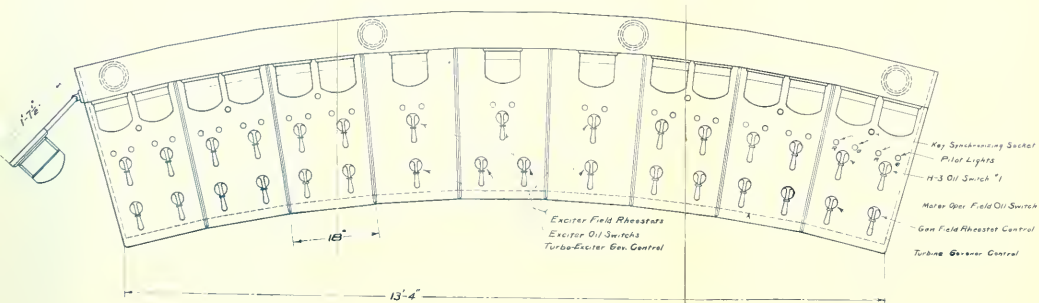
Scale 1" = 1'

SWITCHBOARDS
FOR THE
PROPOSED HYDRO-ELECTRIC
POWER DEVELOPMENT
ON THE
TALLAPOOSA RIVER
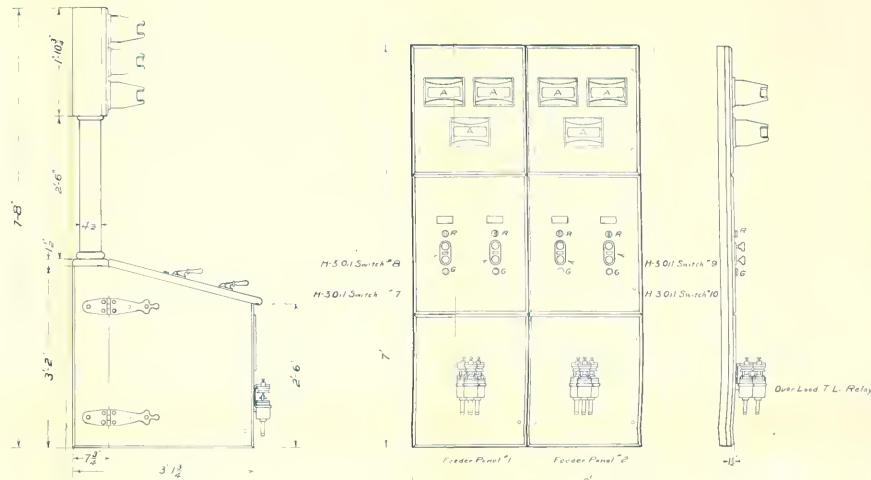TALLAPOOSA CO. ALA.

A THESIS
TO
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BY
Dwight Whitacre
Harold A. Langstaff

PLATE #8.

Plan of Proposed Development of

Tallapoosa River at Cherokee

Power Site Alabama U.S.

Scale

Contour Interval 10 Feet

N

PLATE #1.

Power House

Tail Race

Bulkhead

Head-gates

Fore-bay

Sec. A

Sec. B

Sec. C

Sec. D

Sec. E

Sec. F

Sec. G

PROFILE VIEW

A   B   C   D   E

110
100
90
Spillway for Flood Stages.   Main   Spillway.   Spillway   for   Flood
70
60
50
40
30
20
10
Elevation 0' Low Water Mark.
-10
-20 Line of Rock   Toe of Dam
30
40 HARD Bottom of Cut off Trench
50

MAS

E PROPOS
POWE

TALL
TALL

Direction of Flow of River

A   B   C   D   E

Up Stream Face

This Section of
Bank to be
Excavated to 81 Elev.
84'

Main   Spillway   328'   Main   Spillway
Spillway for Flood Stages   64   Spillway   for   Flo
167   76'   25'

Down   Stream

Line   of   Reference

228   180 160 148 120   70.5 60'   0   60' 72   120'   180   240   300'   360 381.5   420

A   B   C   D   E

PLAN   VIEW.

D   E

Spillway   for   Flood   Stages

Retaining Wall.

90'
81'
80'
70'
60'
50'
40'
30'
20'
10'
0
-10'
-20'
-30'
-40'
-50'

of Rock   Toe of Dam

OUTLINE
OF
MASONRY   DAM
FOR THE
PROPOSED HYDRO-ELECTRIC
POWER   DEVELOPMENT
ON THE
TALLAPOOSA   RIVER
TALLAPOOSA CO.   ALA.

A THESIS
TO
ARMOUR INSTITUTE OF TECHNOLOGY
BY
Harold O. P. Langstaff
Dwight A. Whitaker.
Ralph W. Ross.

Bullkhead

Fore Bay

Wall Through Which Penstocks Pass

180'

213'

203'

Spillway   for Flood   Stages

257'

H

100'

Retaining Wall

300'   360' 381.5'   420   480'   540'   600'   660'   720' 731.5' 790'

D   E

Scale 1' = 30 FT.

PLATE # 3

Plan of Proposed Development of
Tallapoosa River at Cherokee
Power Site Alabama U.S.
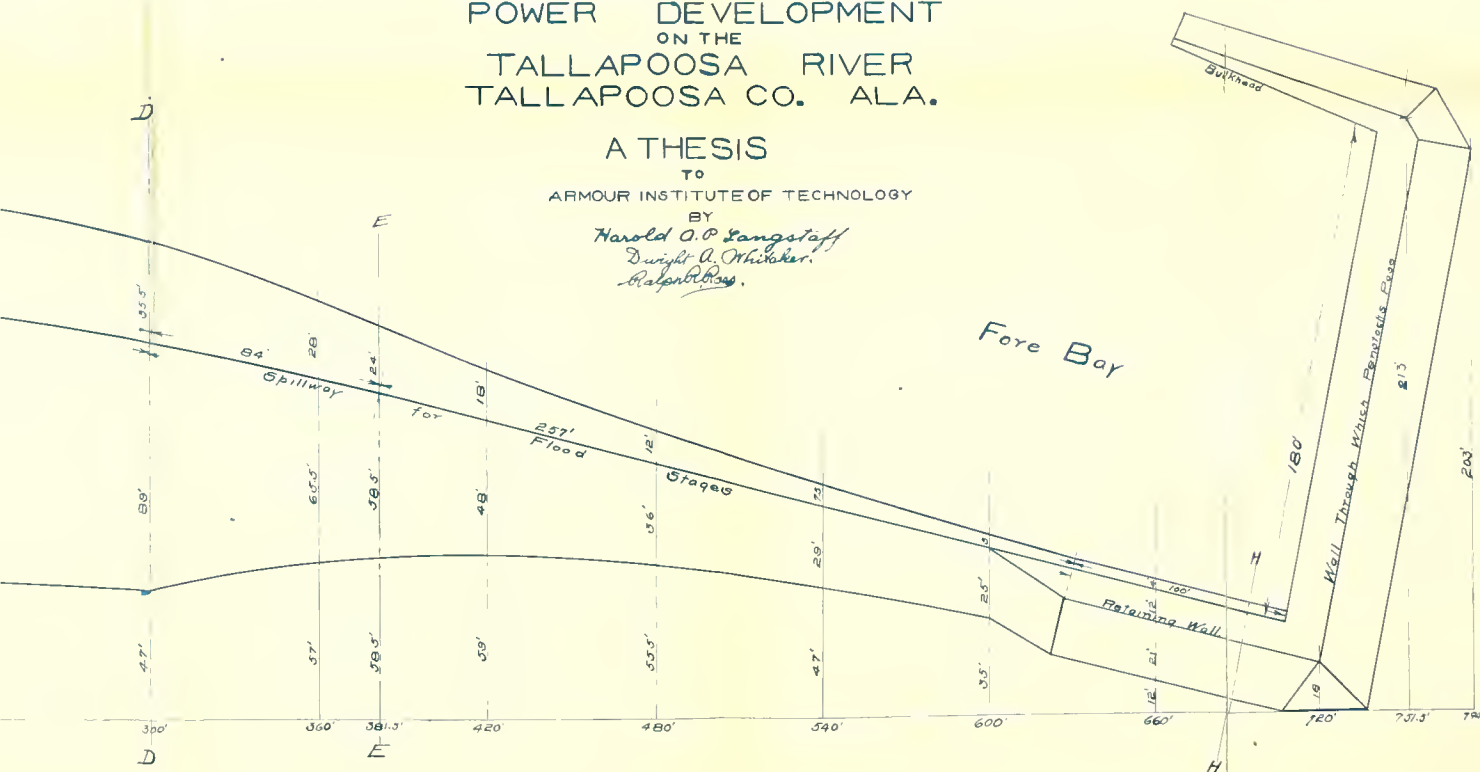
Scale

Contour Interval 10 Feet

PLATE "1

FLOOD WATER LEVEL

85.6'

FWL
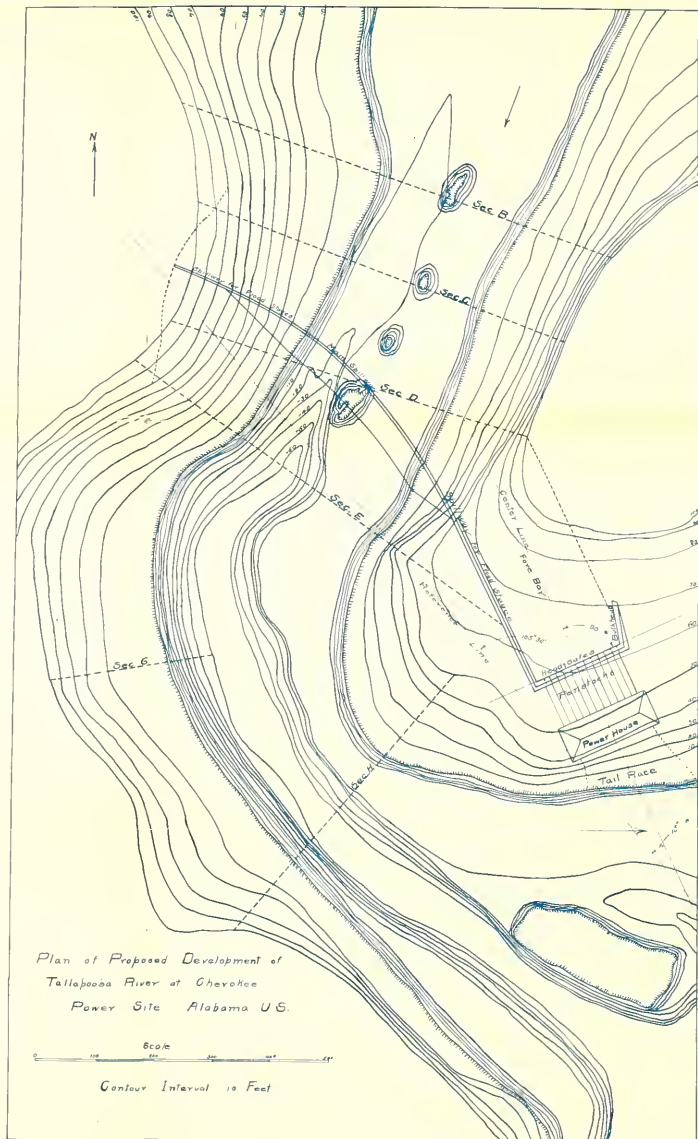
MASONRY DAM
FOR THE
PROPOSED HYDRO-ELECTRIC
POWER DEVELOPMENT
ON THE
TALLAPOOSA RIVER
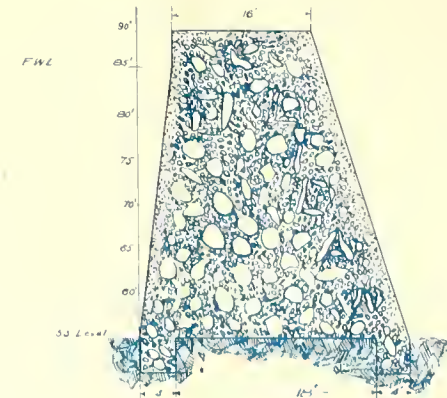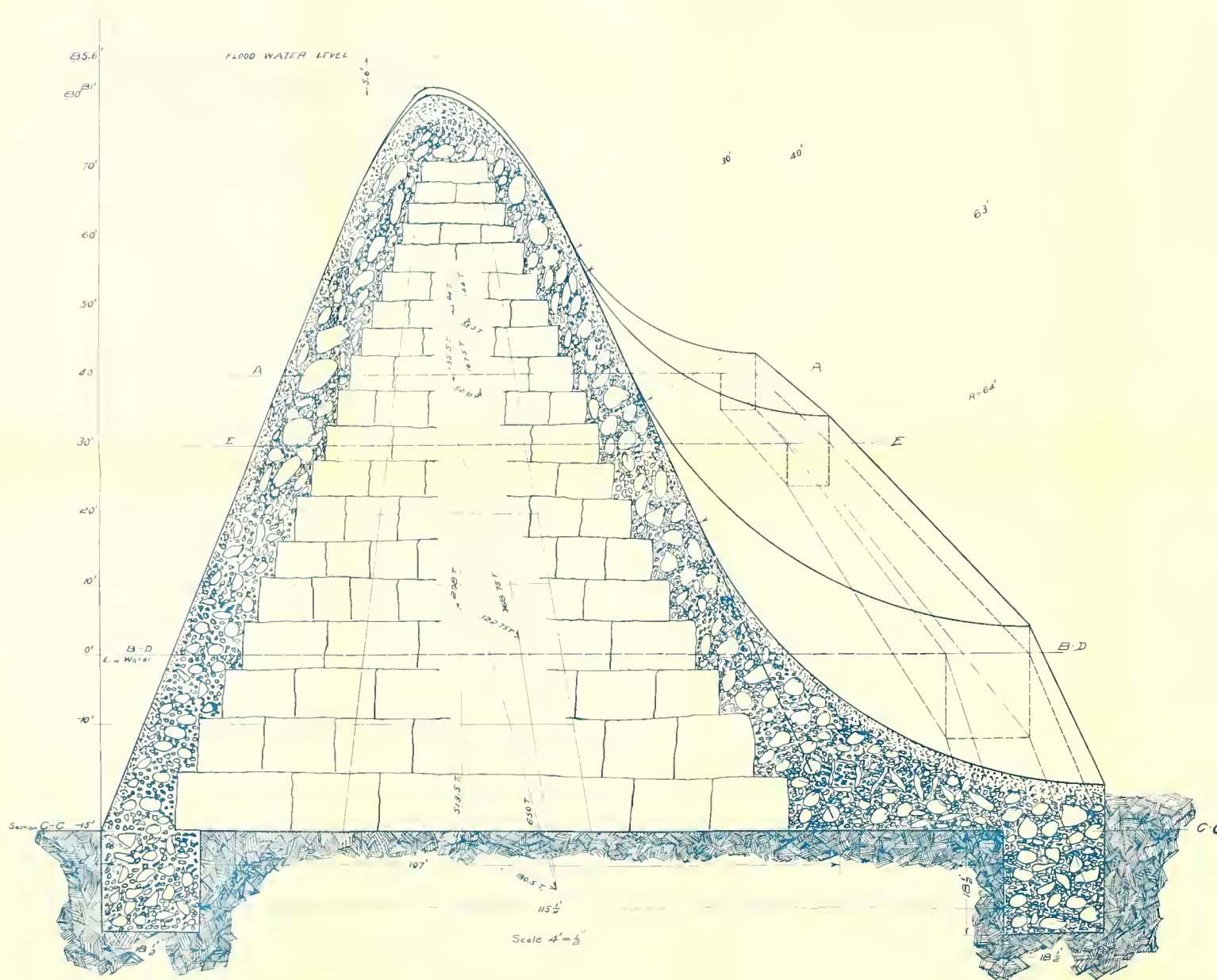TALLAPOOSA CO. ALA.

A THESIS
TO
ARMOUR INSTITUTE OF TECHNOLOGY
BY
Dwight A. Whitaker.
Harold A. R. Langstaff.
Ralph B. Ross.

Scale 4' = ⅛"

PLATE #2.